(B) Graph the following two equations in the same coordinate system:

$$2x + 3y = 12 \qquad 3x - 2y = 12$$

(C) From your observations in parts (A) and (B), describe the apparent relationship of the graphs of

$$Ax + By = C \quad \text{and} \quad Bx - Ay = C$$

65. Describe the relationship between the graphs of $f(x) = mx + b$ and $g(x) = |mx + b|$, $m \neq 0$, and illustrate with examples. Is $g(x)$ always, sometimes, or never a linear function?

66. Describe the relationship between the graphs of $f(x) = mx + b$ and $g(x) = m|x| + b$, $m \neq 0$, and illustrate with examples. Is $g(x)$ always, sometimes, or never a linear function?

APPLICATIONS

Business & Economics

67. *Simple interest.* If $P (the principal) is invested at an interest rate of r, then the amount A that is due after t years is given by

$$A = Prt + P$$

If $100 is invested at 6% ($r = 0.06$), then $A = 6t + 100$, $t \geq 0$.

(A) What will $100 amount to after 5 years? After 20 years?

(B) Sketch a graph of $A = 6t + 100$ for $0 \leq t \leq 20$.

(C) Find the slope of the graph and interpret verbally.

68. *Simple interest.* Use the simple interest formula from Problem 67. If $1,000 is invested at 7.5% ($r = 0.075$), then $A = 75t + 1{,}000$, $t \geq 0$.

(A) What will $1,000 amount to after 5 years? After 20 years?

(B) Sketch a graph of $A = 75t + 1{,}000$ for $0 \leq t \leq 1{,}000$.

(C) Find the slope of the graph and interpret verbally.

69. *Cost function.* The management of a company that manufactures surfboards has fixed costs (at 0 output) of $200 per day and total costs of $3,800 per day at a daily output of 20 boards.

(A) Assuming the total cost per day, $C(x)$, is linearly related to the total output per day, x, write an equation for the cost function.

(B) What are the total costs for an output of 12 boards per day?

(C) Graph the cost function for $0 \leq x \leq 20$.

70. *Cost function.* Repeat Problem 69 if the company has fixed costs of $300 per day and total costs per day at an output of 20 boards of $5,100.

71. *Price–demand function.* A manufacturing company is interested in introducing a new power mower. Its market research department gave the management the price–demand forecast listed in Table 3.

Table 3
PRICE–DEMAND

DEMAND x	WHOLESALE PRICE ($) $p(x)$
0	200
2,400	160
4,800	120
7,800	70

(A) Plot these points, letting $p(x)$ represent the price at which x number of mowers can be sold (demand). Label the horizontal axis x.

(B) Note that the points in part (A) lie along a straight line. Find an equation for the price–demand function.

(C) What would be the price for a demand of 3,000 units?

(D) Write a brief verbal interpretation of the slope of the line found in part (B).

72. *Depreciation.* Office equipment was purchased for $20,000 and is assumed to have a scrap value of $2,000 after 10 years. If its value is depreciated linearly (for tax purposes) from $20,000 to $2,000:

(A) Find the linear equation that relates value (V) in dollars to time (t) in years.

(B) What would be the value of the equipment after 6 years?

(C) Graph the equation for $0 \leq t \leq 10$.

(D) Write a brief verbal interpretation of the slope of the line found in part (A).

Merck & Co., Inc. is the world's largest pharmaceutical company. Problems 73 and 74 refer to the data in Table 4 taken from the company's 1993 annual report.

Table 4
SELECTED FINANCIAL DATA FOR MERCK & CO., INC.

(BILLION $)	1988	1989	1990	1991	1992
SALES	5.9	6.5	7.7	8.6	9.7
NET INCOME	1.2	1.5	1.8	2.1	2.4

73. *Sales analysis.* A mathematical model for Merck's sales is given by

$$f(x) = 5.74 + 0.97x$$

where $x = 0$ corresponds to 1988.

(A) Complete the following table. Round values of $f(x)$ to one decimal place.

x	0	1	2	3	4
SALES	5.9	6.5	7.7	8.6	9.7
$f(x)$					

(B) Sketch the graph of f and the sales data on the same axes.

(C) Use the modeling equation to estimate the sales in 1993. In 2000.

(D) Write a brief verbal description of the company's sales from 1988 to 1992.

74. *Income analysis.* A mathematical model for Merck's income is given by

$$f(x) = 1.2 + 0.3x$$

where $x = 0$ corresponds to 1988.

(A) Complete the following table. Round values of $f(x)$ to one decimal place.

x	0	1	2	3	4
NET INCOME	1.2	1.5	1.8	2.1	2.4
$f(x)$					

(B) Sketch the graph of f and the income data on the same axes.

(C) Use the modeling equation to estimate the income in 1993. In 2000.

(D) Write a brief verbal description of the company's income from 1988 to 1992.

Life Sciences

75. *Nutrition.* In a nutrition experiment, a biologist wants to prepare a special diet for the experimental animals. Two food mixes, A and B, are available. If mix A contains 20% protein and mix B contains 10% protein, what combination of each mix will provide exactly 20 grams of protein? Let x be the amount of A used and let y be the amount of B used. Then write a linear equation relating x, y, and 20. Graph this equation for $x \geq 0$ and $y \geq 0$.

76. *Ecology.* As one descends into the ocean, pressure increases linearly. The pressure is 15 pounds per square inch on the surface and 30 pounds per square inch 33 feet below the surface.

(A) If p is the pressure in pounds and d is the depth below the surface in feet, write an equation that expresses p in terms of d. [*Hint:* Find an equation of the line that passes through (0, 15) and (33, 30).]

(B) What is the pressure at 12,540 feet (the average depth of the ocean)?

(C) Graph the equation for $0 \leq d \leq 12{,}540$.

(D) Write a brief verbal interpretation of the slope of the line found in part (A).

Social Sciences

77. *Psychology.* In an experiment on motivation, J. S. Brown trained a group of rats to run down a narrow passage in a cage to obtain food in a goal box. Using a harness, he then connected the rats to an overhead wire that was attached to a spring scale. A rat was placed at different distances d (in centimeters) from the goal box, and the pull p (in grams) of the rat toward the food was measured. Brown found that the relationship between these two variables was very close to being linear and could be approximated by the equation

$$p = -\tfrac{1}{4}d + 70 \qquad 30 \leq d \leq 175$$

(See J. S. Brown, *Journal of Comparative and Physiological Psychology*, 1948, 41:450–465.)

(A) What was the pull when $d = 30$? When $d = 175$?

(B) Graph the equation.

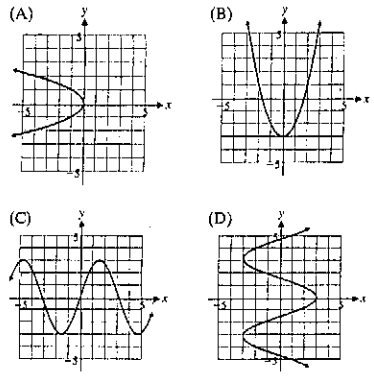
(C) What is the slope of the line?

REVIEW EXERCISE

Work through all the problems in this chapter review and check your answers in the back of the book. Answers to all review problems are there along with section numbers in italics to indicate where each type of problem is discussed. Where weaknesses show up, review appropriate sections in the text.

A

1. Use point-by-point plotting to sketch a graph of $y = 5 - x^2$. Use integer values for x from -3 to 3.
2. Indicate whether each graph specifies a function:



3. For $f(x) = 2x - 1$ and $g(x) = x^2 - 2x$, find:
   (A) $f(-2) + g(-1)$ (B) $f(0) \cdot g(4)$
   (C) $\dfrac{g(2)}{f(3)}$ (D) $\dfrac{f(3)}{g(2)}$
4. Use the graph of function f in the figure to determine (to the nearest integer) x or y as indicated.
   (A) $y = f(0)$ (B) $4 = f(x)$
   (C) $y = f(3)$ (D) $3 = f(x)$
   (E) $y = f(-6)$ (F) $-1 = f(x)$

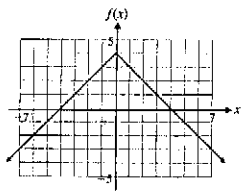


Figure for 4

5. Sketch a graph of each of the functions in parts (A)–(D) using the graph of function f in the figure below.
   (A) $y = -f(x)$ (B) $y = f(x) + 4$
   (C) $y = f(x - 2)$ (D) $y = -f(x + 3) - 3$

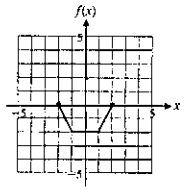


Figure for 5

6. Refer to the figure below.

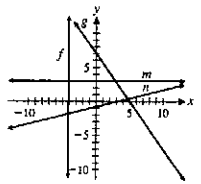


Figure for 6

   (A) Identify the graphs of any linear functions with positive slopes.
   (B) Identify the graphs of any linear functions with negative slopes.
   (C) Identify the graphs of any constant functions. What are their slopes?
   (D) Identify any graphs that are not graphs of functions. What can you say about their slopes?
7. Write an equation in the form $y = mx + b$ for a line with slope $-\frac{2}{3}$ and y intercept 6.
8. Write the equations of the vertical line and the horizontal line that pass through $(-6, 5)$.
9. Sketch a graph of $2x - 3y = 18$. What are the intercepts and slope of the line?
10. Indicate which equations define a quadratic function with x the independent variable.
    (A) $y^2 = 4 - x^2$ (B) $x^2 - 3 = y$
    (C) $y = -2(x - 3)^2 + 1$ (D) $y = x(x + 7)$
    (E) $y = 3x + 9$ (F) $y = 0.2x^2 - 5.7$

11. Match each equation with a graph of one of the functions f, g, m, or n in the figure.
    (A) $y = (x - 2)^2 - 4$ (B) $y = -(x + 2)^2 + 4$
    (C) $y = -(x - 2)^2 + 4$ (D) $y = (x + 2)^2 - 4$

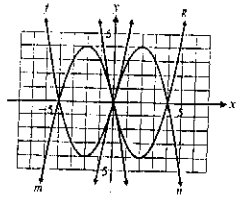


Figure for 11

12. Referring to the graph of function f in the figure for Problem 11 and using known properties of quadratic functions, find each of the following to the nearest integer:
    (A) Intercepts (B) Vertex
    (C) Maximum or minimum (D) Range
    (E) Increasing interval (F) Decreasing interval

B

13. Indicate which of the following equations define a linear function or a constant function:
    (A) $2x - 3y = 5$ (B) $x = -2$
    (C) $y = 4 - 3x$ (D) $y = -5$
    (E) $x = 3y + 5$ (F) $\dfrac{x}{2} - \dfrac{y}{3} = 1$
14. Find the domain of each function:
    (A) $f(x) = \dfrac{2x - 5}{x^2 - x - 6}$ (B) $g(x) = \dfrac{3x}{\sqrt{5 - x}}$
15. The function g is defined by $g(x) = 2x - 3\sqrt{x}$. Translate into a verbal definition.
16. Describe the graphs of $x = -3$ and $y = 2$. Graph both simultaneously in the same rectangular coordinate system.
17. Let $f(x) = 0.4x(x + 4)(2 - x)$.
    C (A) Sketch a graph of f on graph paper by first plotting points using odd integer values of x from -3 to 3. Then complete the graph using a graphing utility.
    (B) Discuss the number of solutions of each of the following equations:
    $$f(x) = 3 \qquad f(x) = 2 \qquad f(x) = 1$$
    (C) Approximate the solutions of each equation in part (B) to two decimal places.
18. Find $\dfrac{f(2 + h) - f(2)}{h}$ for $f(x) = 3 - 2x$.
19. Find $\dfrac{f(a + h) - f(a)}{h}$ for $f(x) = x^2 - 3x + 1$.
20. Explain how the graph of $m(x) = -|x - 4|$ is related to the graph of $y = |x|$.
21. Explain how the graph of $g(x) = 0.3x^3 + 3$ is related to the graph of $y = x^3$.
22. The following graph is the result of applying a sequence of transformations to the graph of $y = x^2$. Describe the transformations verbally and write an equation for the given graph.

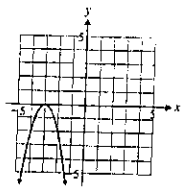


Figure for 22

23. The graph of a function f is formed by vertically expanding the graph of $y = \sqrt{x}$ by a factor of 2, and shifting it to the left 3 units and down 1 unit. Find an equation for function f and graph it for $-5 \leq x \leq 5$ and $-5 \leq y \leq 5$.
24. Let
$$f(x) = \begin{cases} -x - 2 & \text{for } x < 0 \\ 0.2x^2 & \text{for } x \geq 0 \end{cases}$$
    (A) Sketch the graph of f.
    (B) Find any points of discontinuity.
    C (C) Check by graphing on a graphing utility.
25. Write the equation of a line through each indicated point with the indicated slope. Write the final answer in the form $y = mx + b$.
    (A) $m = -\frac{2}{3}$; $(-3, 2)$ (B) $m = 0$; $(3, 3)$
26. Write the equation of the line through the two indicated points. Write the final answer in the form $Ax + By = C$.
    (A) $(-3, 5), (1, -1)$ (B) $(-1, 5), (4, 5)$
    (C) $(-2, 7), (-2, -2)$
27. Write an equation for the graph shown in the form $y = a(x - h)^2 + k$, where a is either -1 or $+1$ and h and k are integers.

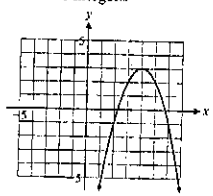


Figure for 27

p. 50-51 #69, 77 p-68-69 #2-9 (sketch 7-9)
13, 16, 25, 26

69 (0, 200) (20, 3800)

(a) $\frac{3800-200}{20-0} = \frac{3600}{20} = 180$

$200 = 180(0) + b$

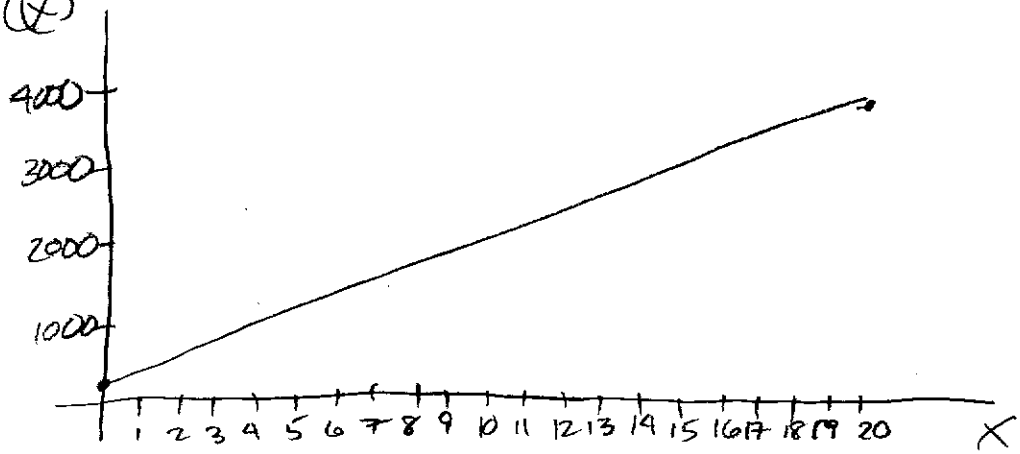
$200 = b$

$C(x) = 180x + 200$

(b) $C(12) = 180(12) + 200$

$\$2360$

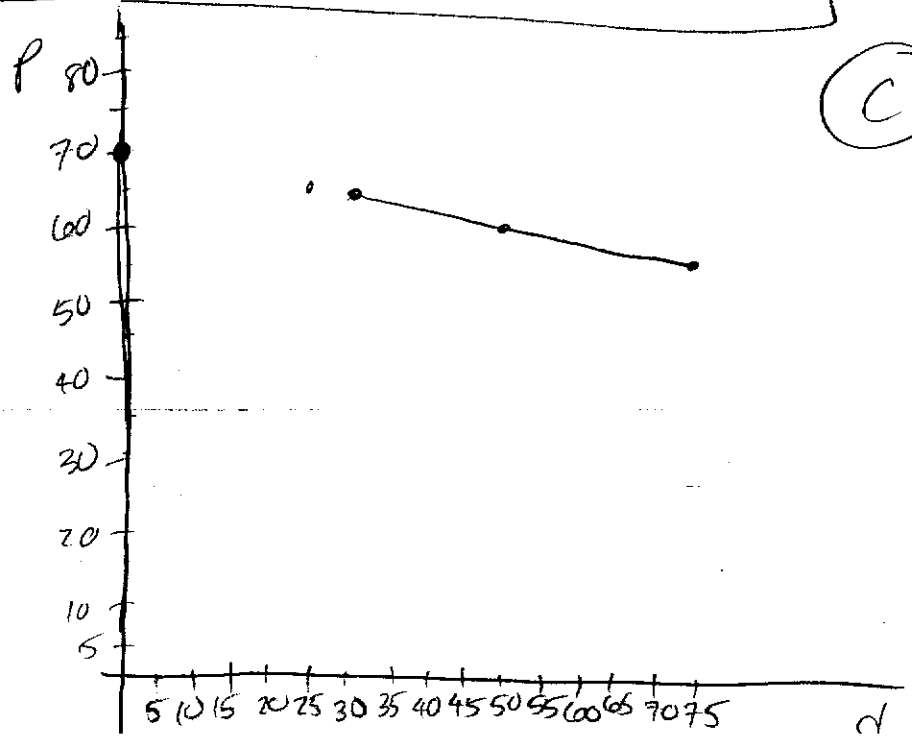
(c)



77 (a) $p = -\frac{1}{5}(30) + 70$ $p = -\frac{1}{5}(175) + 70$

$p(30) = 64$ $p(175) = 35$

(b)



(c) $-\frac{1}{5}$

(2) (A) NO (B) Yes (C) Yes (D) NO

(3) (A) $f(-2)+g(-1) = 2(-2) - 1 + (-1)^2 - 2(-1)$

$= -4 - 1 + 1 + 2$

$= -2$

(b) $f(0) \cdot g(4) = (2(0)-1)(4^2 - 2(4))$

$= (-1)(8)$

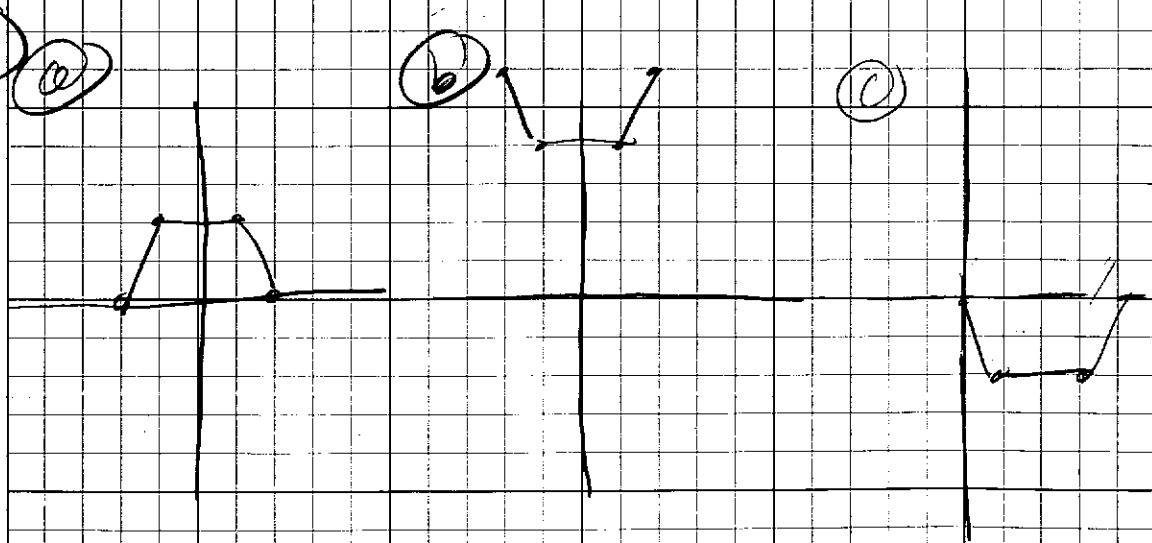
$= -8$

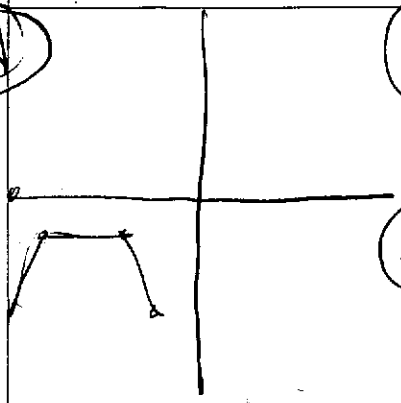
(c) $\frac{g(2)}{f(3)} = \frac{2^2 - 2(2)}{2(3)-1} = \frac{0}{5} = 0$

(d) $\frac{f(3)}{g(2)} = \frac{5}{0} =$ undef

(4) (a) 5 (b) 0 (c) 1 (d) 1 or -1 (e) -2 (f) 5 or -5

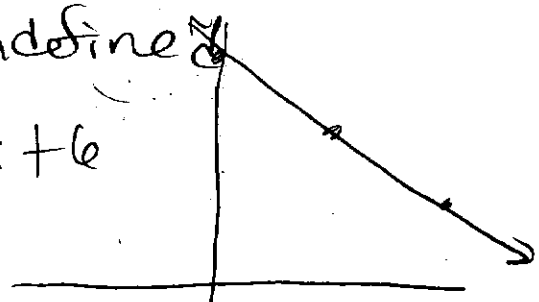
(5) (a) (b) (c)



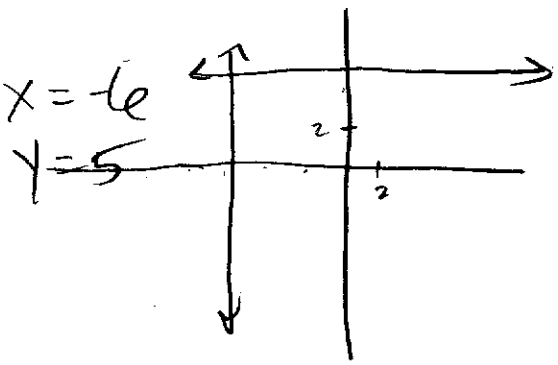
(d) 

(e) (a) n (b) g (c) m, zero
(d) f, undefined

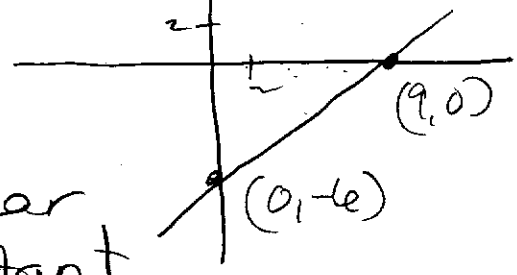
(7) $y = -\frac{2}{3}x + 6$



(6) $x = -6$
$y = -5$

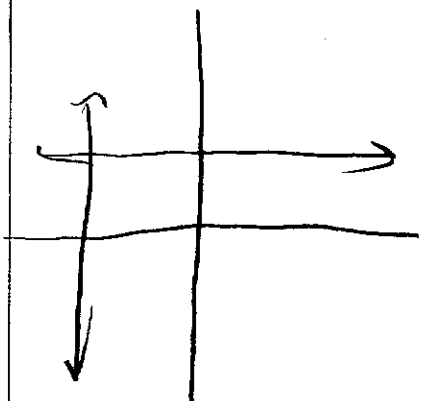


(9)



(13) (a) linear (c) linear
(b) not a function (d) constant
(e) linear (f) linear

(16) $x = -3$ vert $y = 2$ horiz



(26) oops! (a) $\frac{5+1}{-3-1} = \frac{6}{-4} = \frac{-3}{2}$

$-1 = \frac{-3}{2}(1) + b$

$-1 = -\frac{3}{2} + b$

$\frac{1}{2} = b$ $y = -\frac{3}{2}x + \frac{1}{2}$

~~$2y = -3x + 1$~~

$3x + 2y = 1$

(b) $\frac{5-5}{4+1} = 0$

$y = 5$

(c) $\frac{7+2}{-2+2} =$ undef

$x = -2$

(25) (a) $2 = \frac{-2}{3}(3) + b$

$2 = 2 + b$

$0 = b$ $y = -\frac{2}{3}x$

(b) $y = 3$